Electron ID projections

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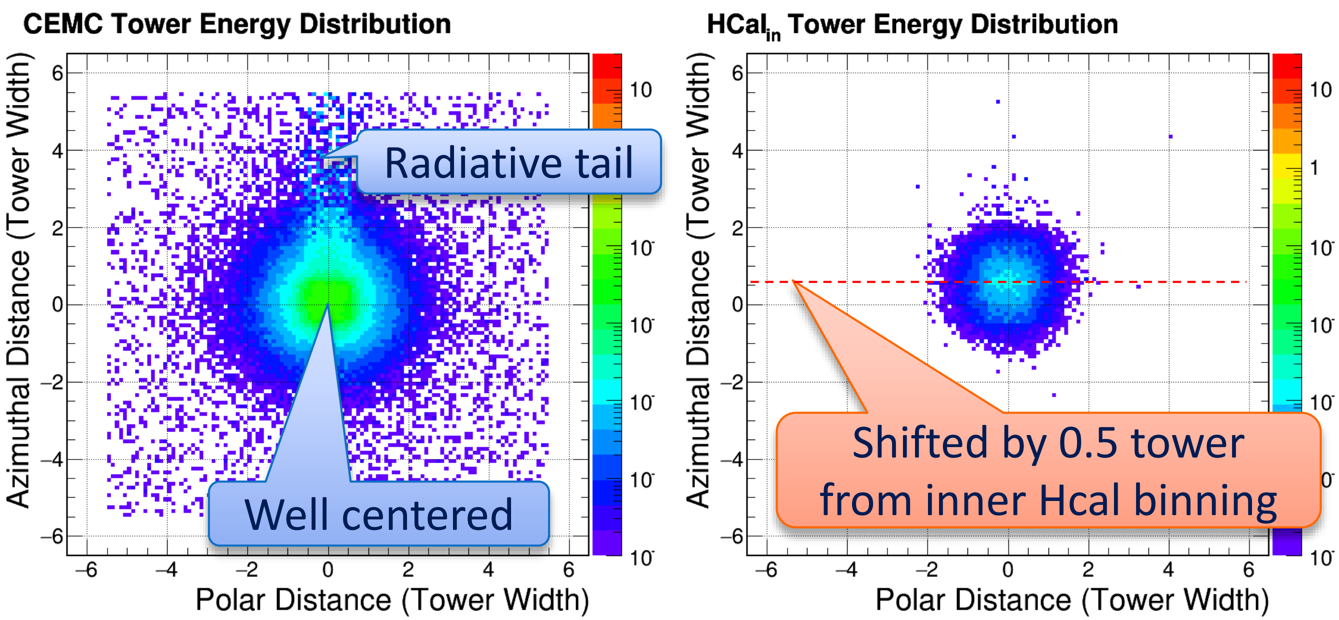
Software tools

- Software: in analysis repository
  - https://github.com/sPHENIX-Collaboration/analysis/tree/master/EMCal-analysis
  - Fun4All analysis module to build condensed DST objects
    → pico-DST file of emcal focused analysis
- Procedure:
  1. From a truth particle
  2. -> Find best track (cut on good track)
  3. -> Project to calorimeters
  4. -> Build cluster around the track projection
  5. -> Likelihood PID based on cluster energy deposition (EMCal/Inner HCal)
  6. -> Shower shape
- Analysis module :
  - EMCal-analysis/EMCalAna: track projection, clustering, truth association
    Mike's evaluator tool are very useful in trace between truth and reco track/towers
  - EMCal-analysis/EMCalLikelihood: assign log-likelihood to track-cluster pairs
- Plot macros: EMCal-analysis/macro

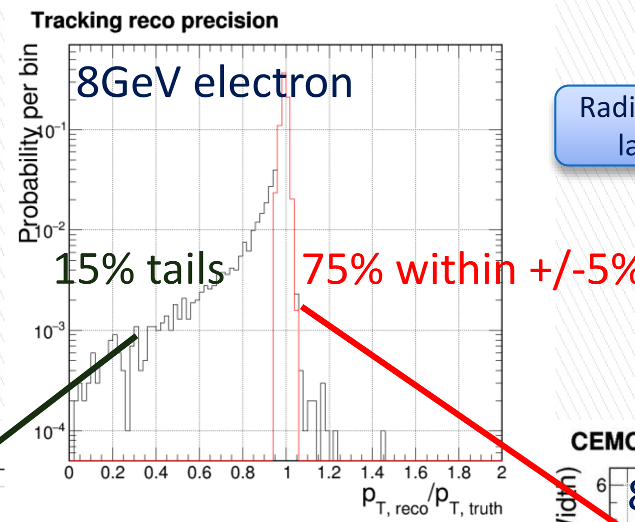
Shower distribution around the track

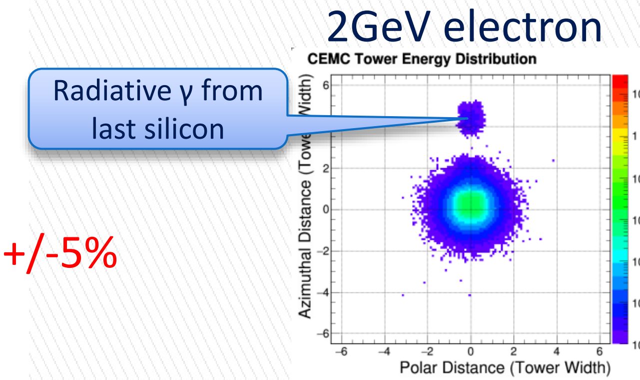
- In discussion about current problem:
  - https://github.com/sPHENIX-Collaboration/coresoftware/pull/69
  - Using this quick solution right now
- Result plot: 8GeV electron track projection to 2D projective SPACAL
- Not shown here though: with 8mm strip at last layer, projection is discretized to 2mm steps at a given vertex point

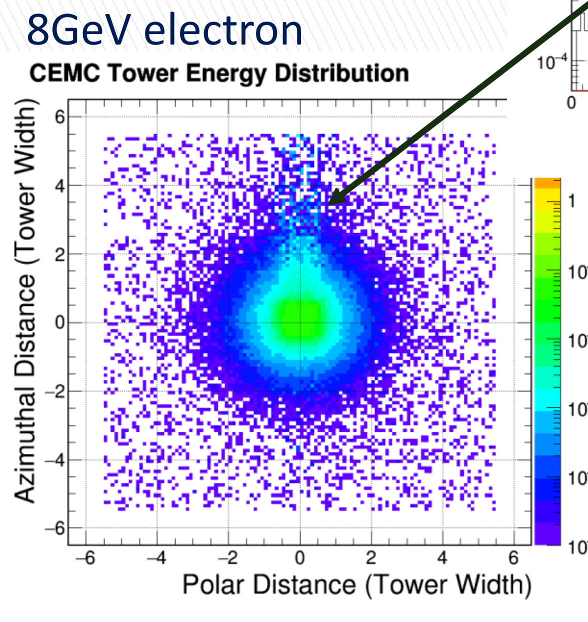


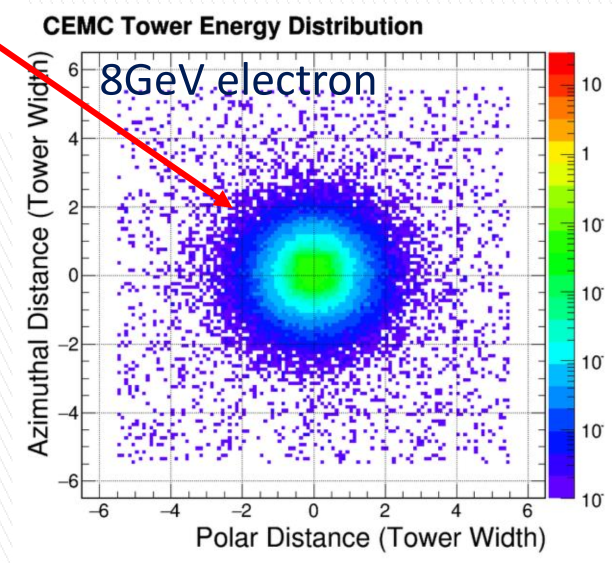
Track projection checks – Removing radiative tails

Full sPHENIX
Single electron + Geant4
+ Digitalization + Tracking









All reconstructed tracks

Track with pT reco within 5% of truth (sample for eID ana.)

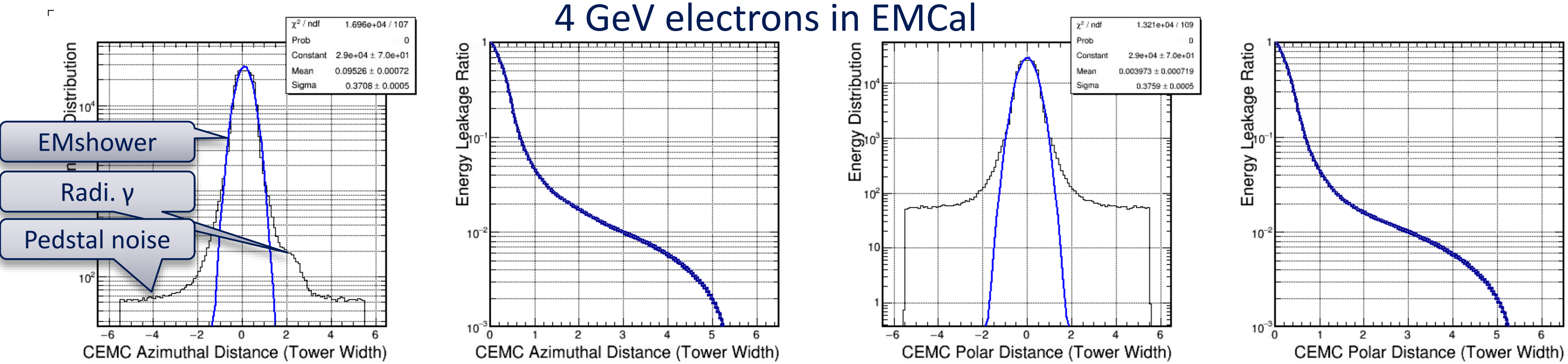
Building cluster based on tower distance to the track production (+shift cor.)

First choice of cluster radius cut is 1.6 tower width in both inner Hcal and EMCal

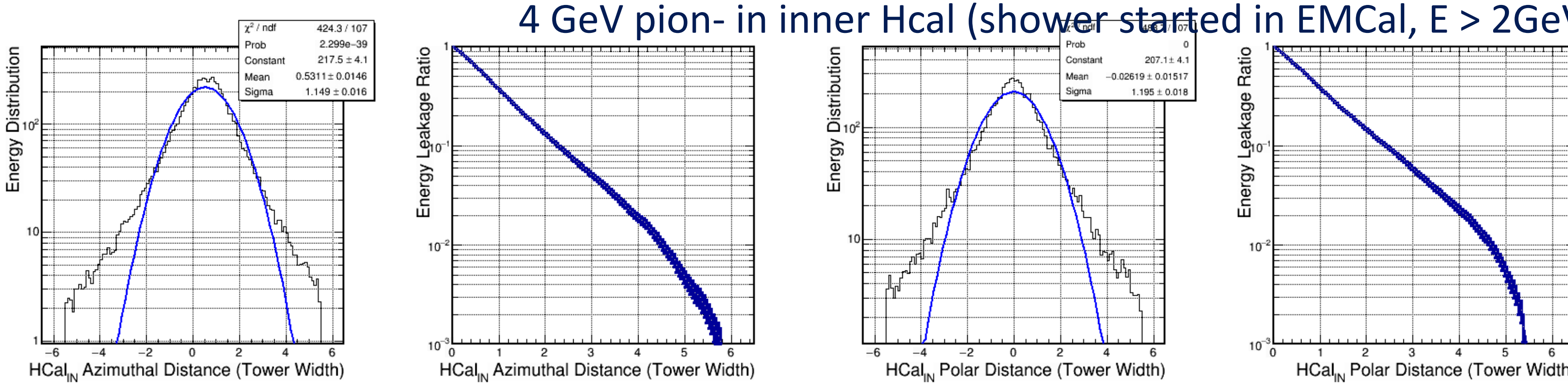
- 98% EM-shower containment in EMCal, 90% hadron shower containment in EMCal, 80% hadron shower containment in inner Hcal
- If shower hit around tower center, neighbor towers are included
- Average cluster size ~ 8 towers, similar but better than 3x3-tower cluster

A tighter cluster radius would further balance reduction of HI background VS leakages (shower size/mismatches, etc.)

4 GeV electrons in EMCal

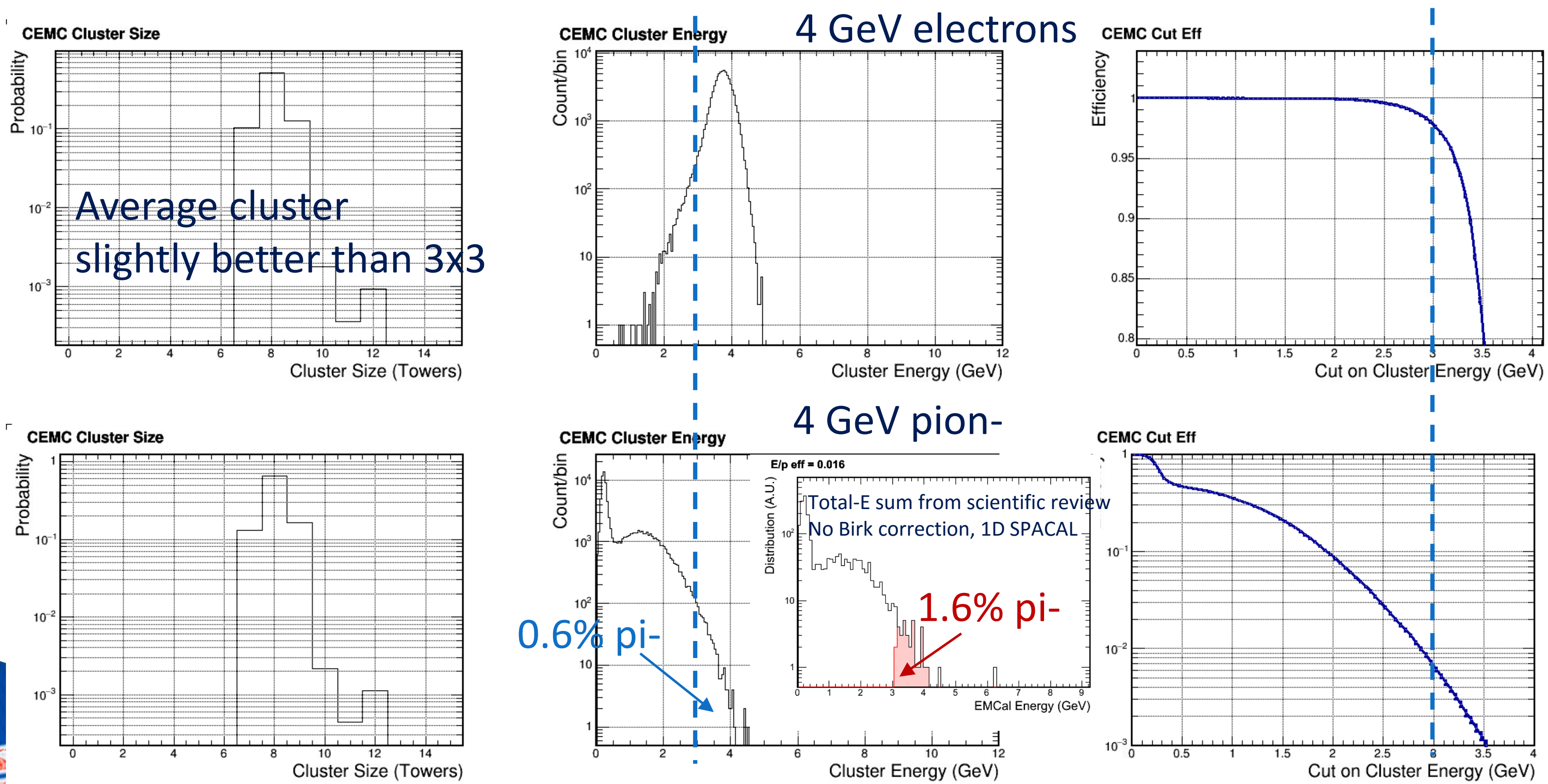


4 GeV pion- in inner Hcal (shower started in EMCal, E > 2GeV)



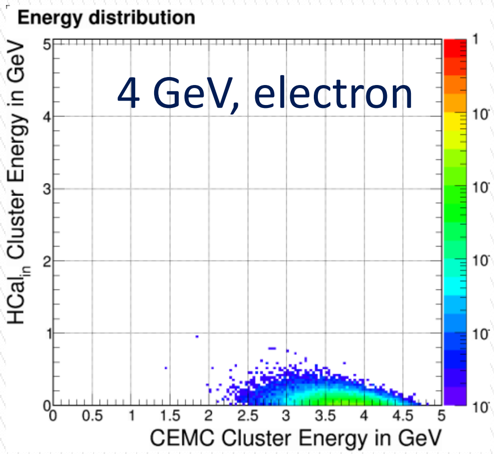
Cluster energy matching, EMCal only
4 GeV shower in 2D proj. SPACAL @ eta=0

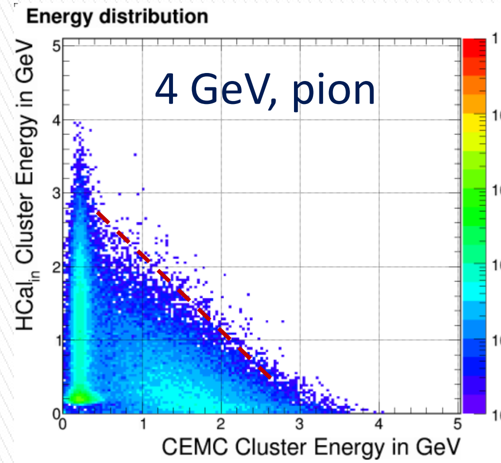
- Simple EMCal cut to illustrate expected performance
- Significant improvement for Birk correction
  - Pion tail reduced from ~ 1.6% to 0.6%

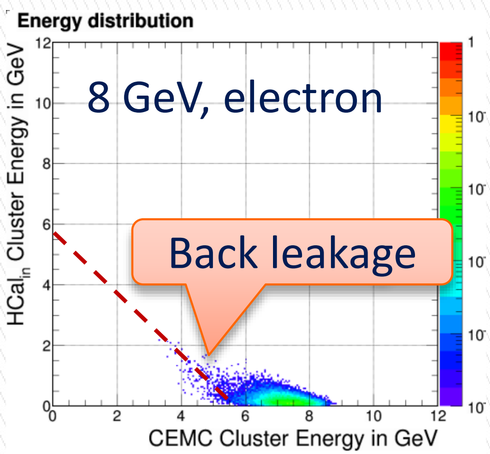


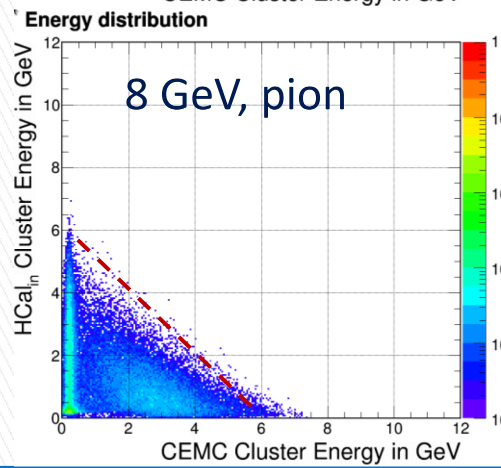
Energy matching with inner HCal

4/8 GeV shower in 2D proj. SPACAL @ eta=0





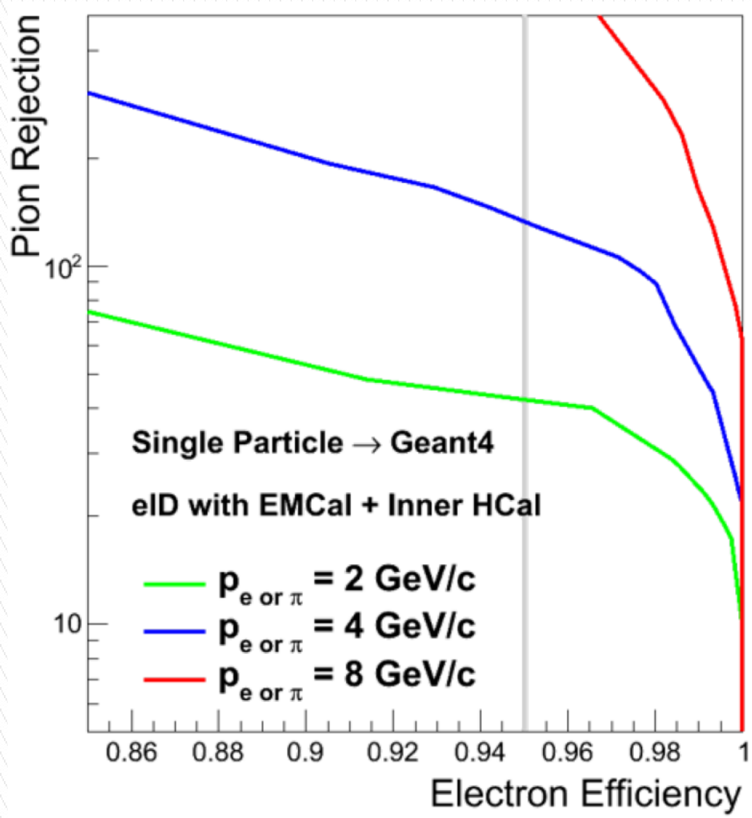


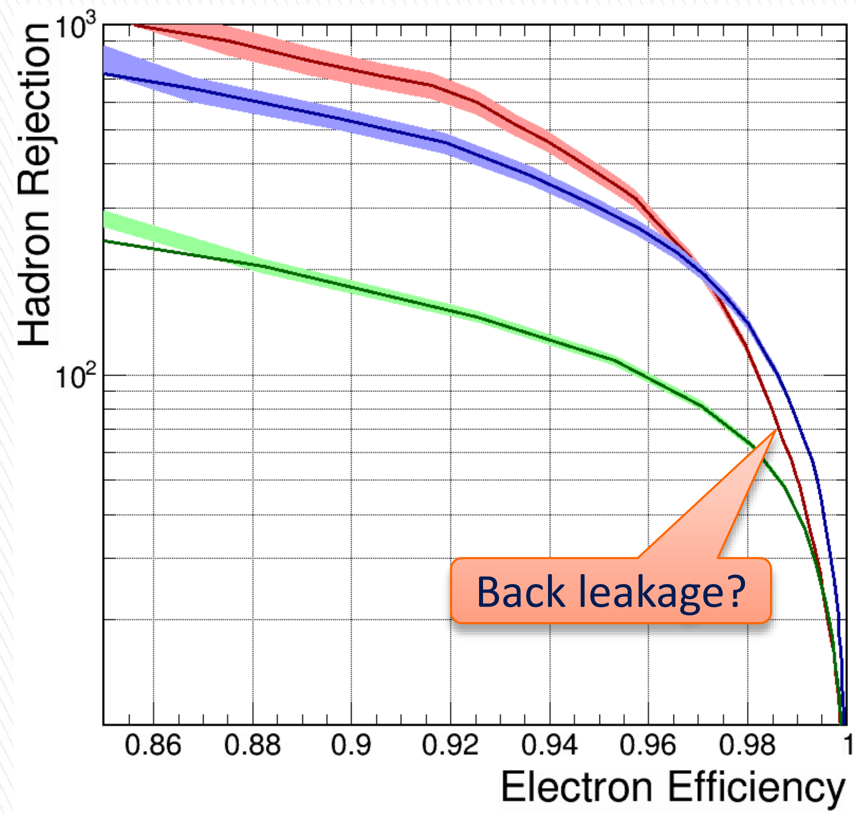


Electron,
anti-radiative cut dp/p<5%

Pion

Comparing to





Scientific review plot

Sum all scintillator energy

1D SPACAL material cut into 2D SPACAL towers

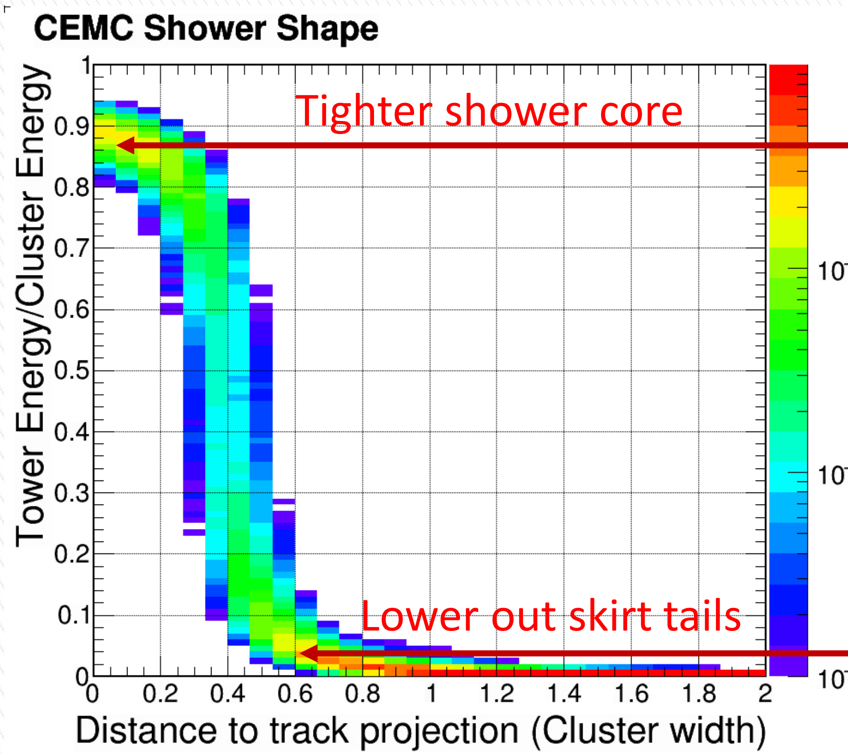
New plot (pro1.beta5)

With Birk corrections

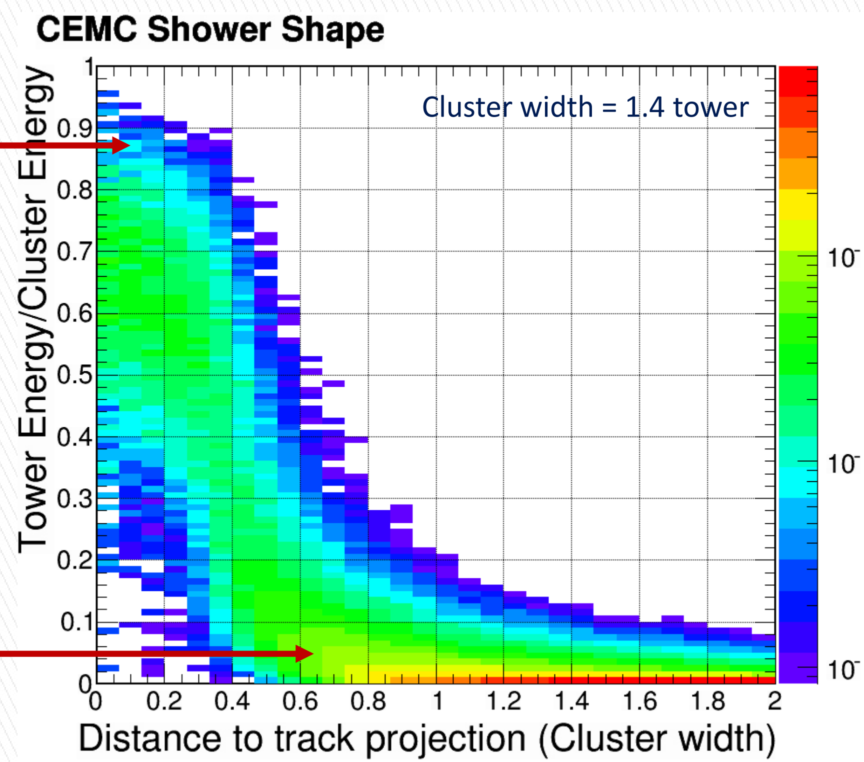
Fully implemented 2D SPACAL

Beyond energy sum: shower shape
8 GeV showers in 2D proj. SPACAL @ eta=0

- Beyond cluster energy deposition, one can build a likelihood based on shower shape
- But we try not relying on it during design stage, as it is more relying on simulation accuracy

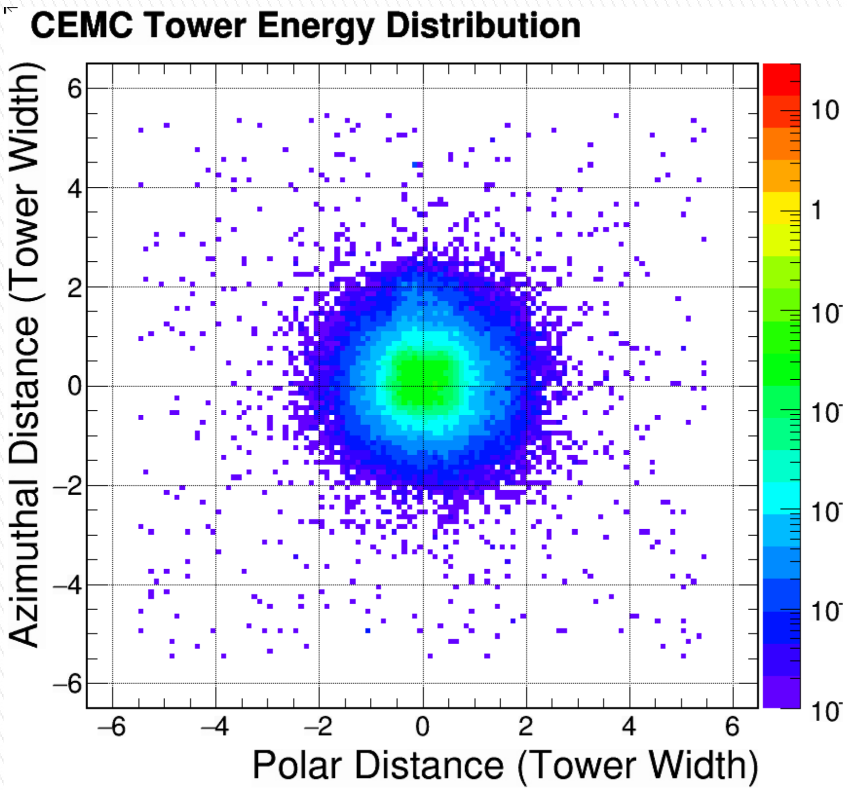


Electron shower

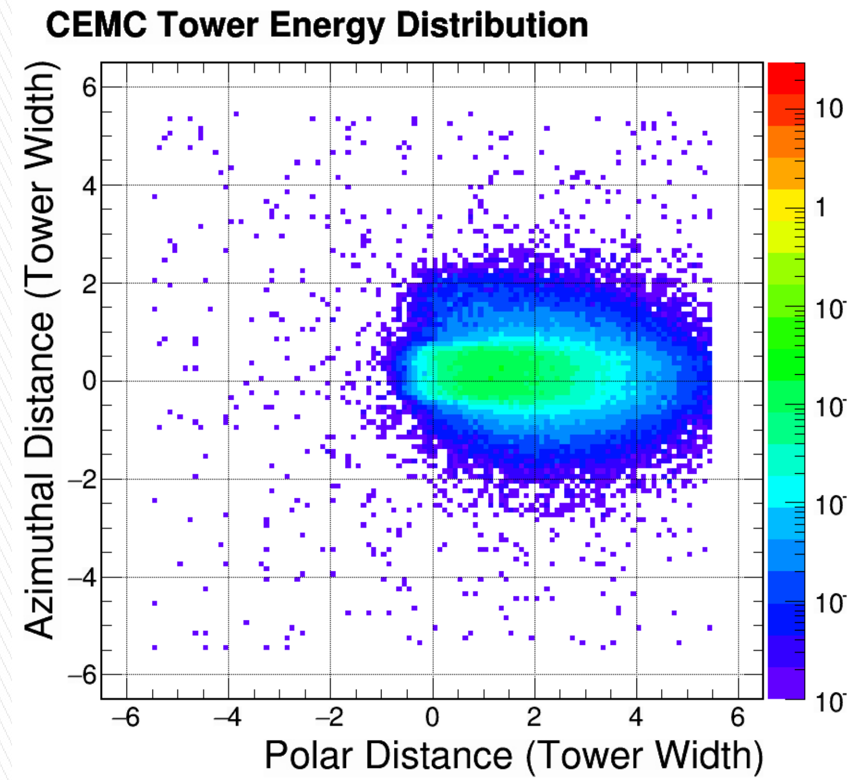


Pion shower (E>3 GeV)

Shower distribution @ forward-most : 8 GeV e- in eta = 0.9-1.0



2D Spacal
Average cluster ~8 towers



1D Spacal
Average cluster ~12+ towers

Summary

- Birk correction has large influence over hadron tails
  - Suppressed the h/e
  - Simple comparison showed x2-3 improvement in pp eID as the pion tail shifted to lower amplitude
- What is going-on now? Embedding
  - Embedding production finished for both 1D and 2D SPACAL
    - Thanks Chris!
  - Analysis job finishing up (most CPU time in tracking in hijing hits)
  - Expect improved electron-ID curve with embedded particle too,
    - Suppressed hadron shower tail
    - Hadron background response in calorimeters
  - Checking it through before showing around...

Extra information

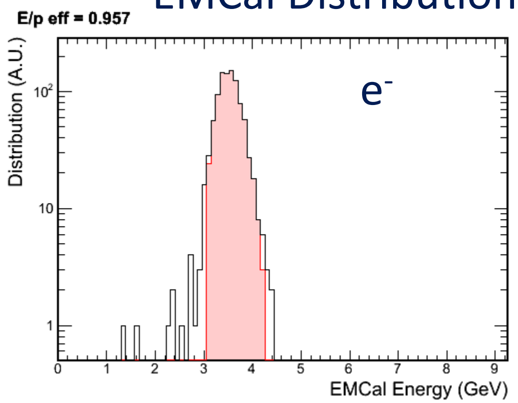
eID and pion rejection in pp : E/p + HCal

4GeV electron and pion-, |η|<0.2

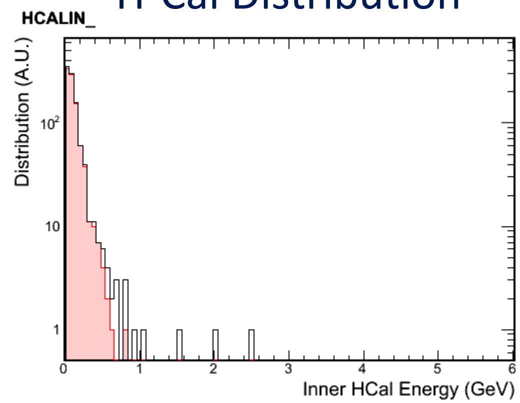
EMCal tower cut : R<3cm, Hcal cut : R<20cm

- all events
- with EMCal E/p cut

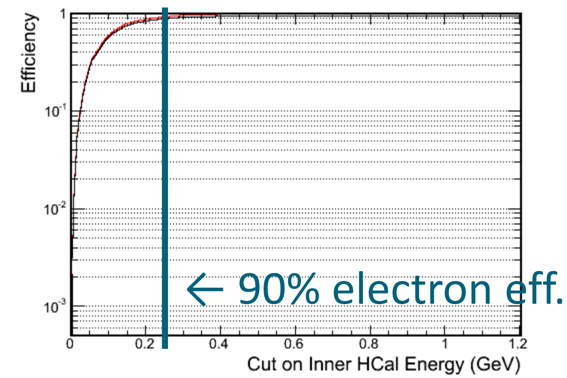
EMCal Distribution



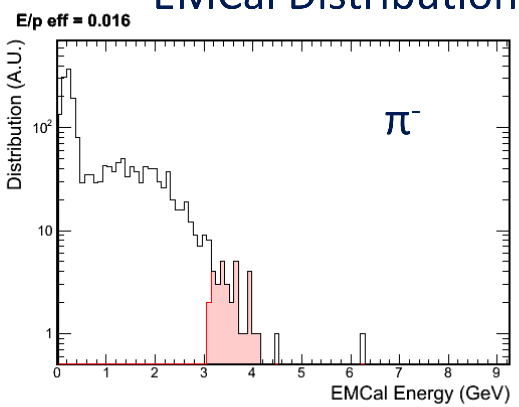
H-Cal Distribution



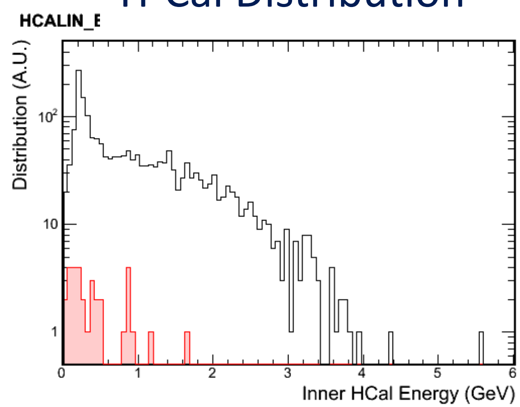
H-Cal Cut Efficiency



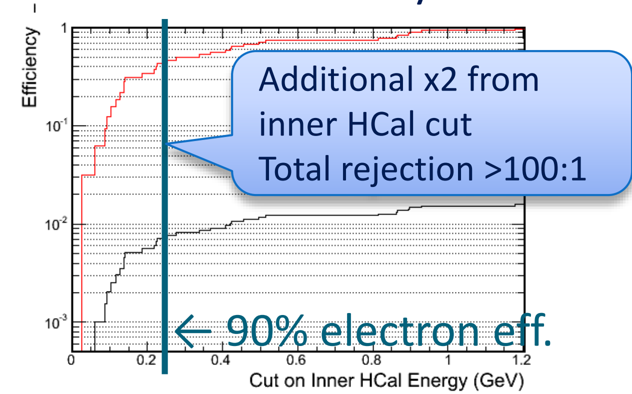
EMCal Distribution



H-Cal Distribution



H-Cal Cut Efficiency

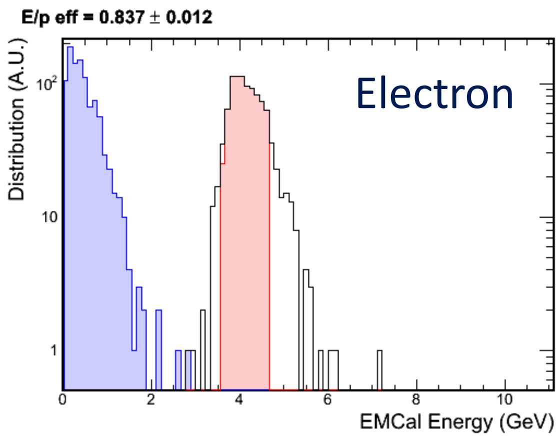


eID in central AuAu, central pseudo-rapidity

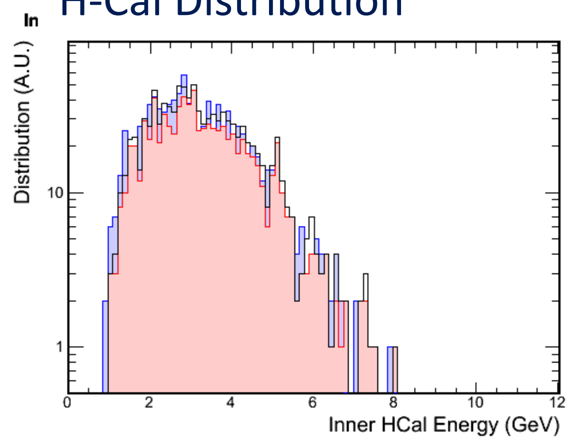
4GeV electron and pion-, |η|<0.2

EMCal tower cut : R<3cm, Hcal cut : R<20cm

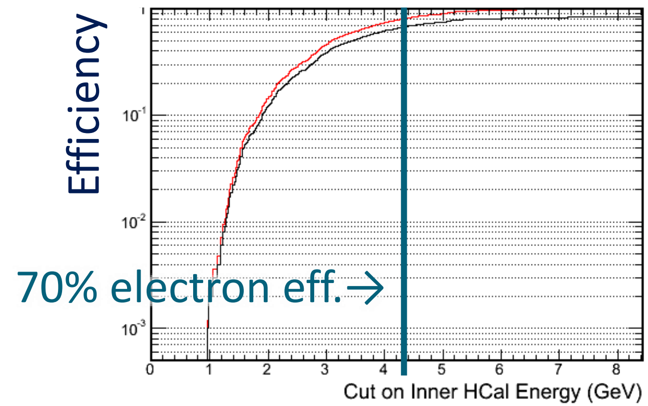
- Hijing background (AuAu 10%C in B-field)
- all c(w/ embedding)
- with EMCal E/p cut (w/ embedding)

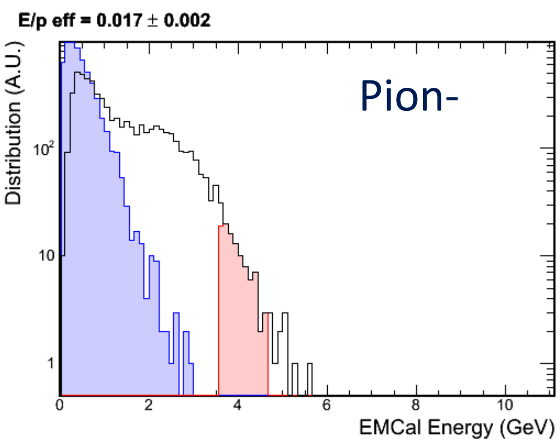


H-Cal Distribution

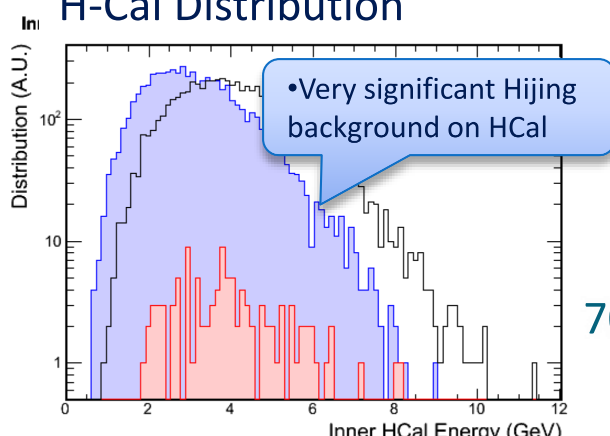


H-Cal Cut Efficiency

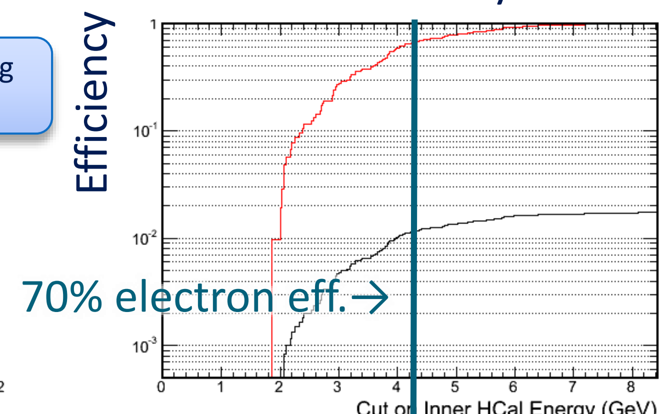




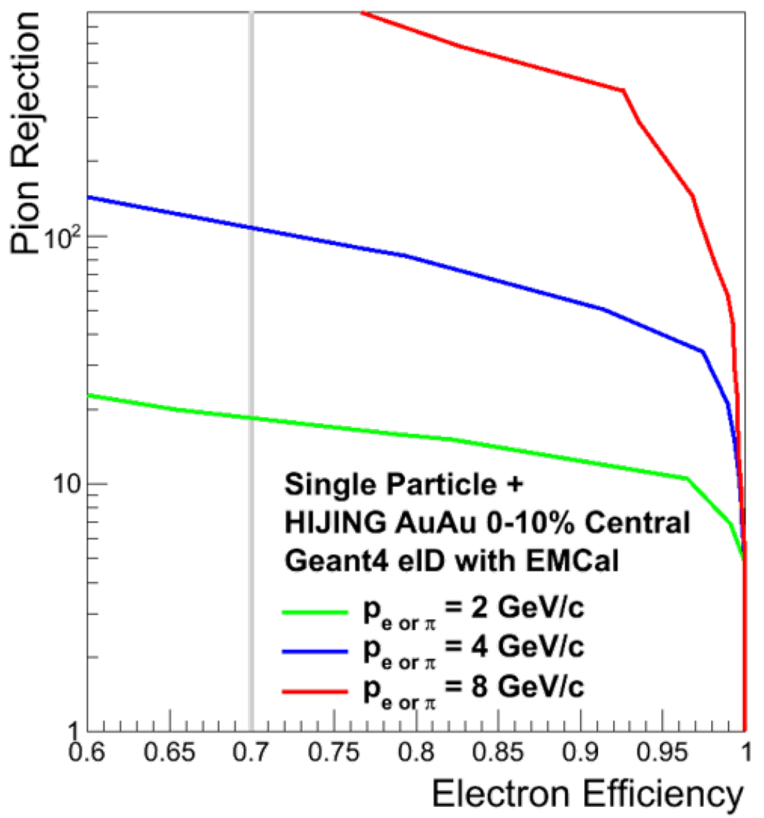
H-Cal Distribution

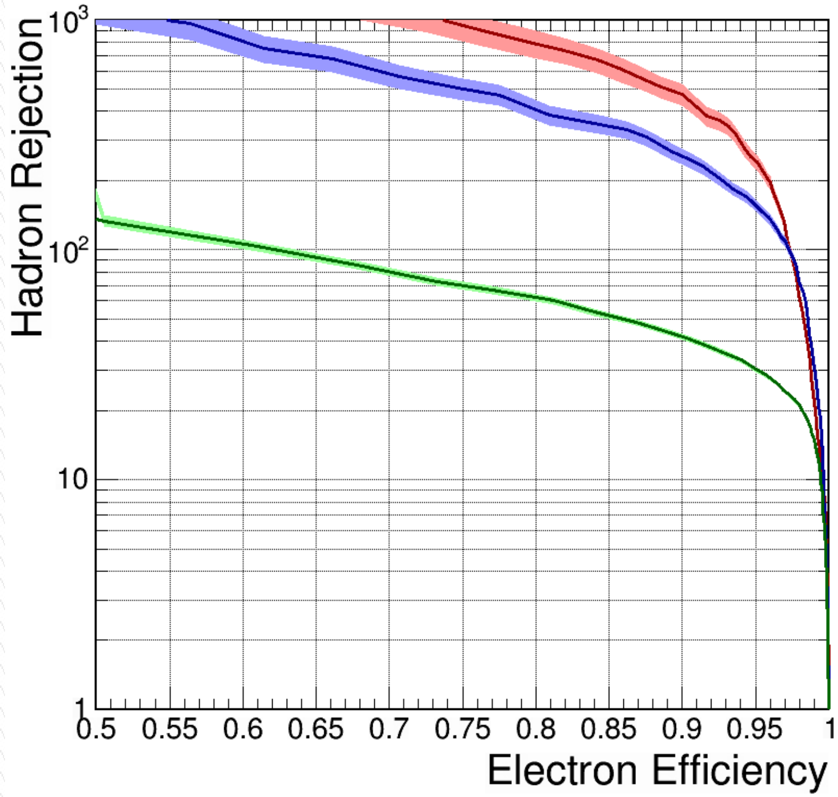


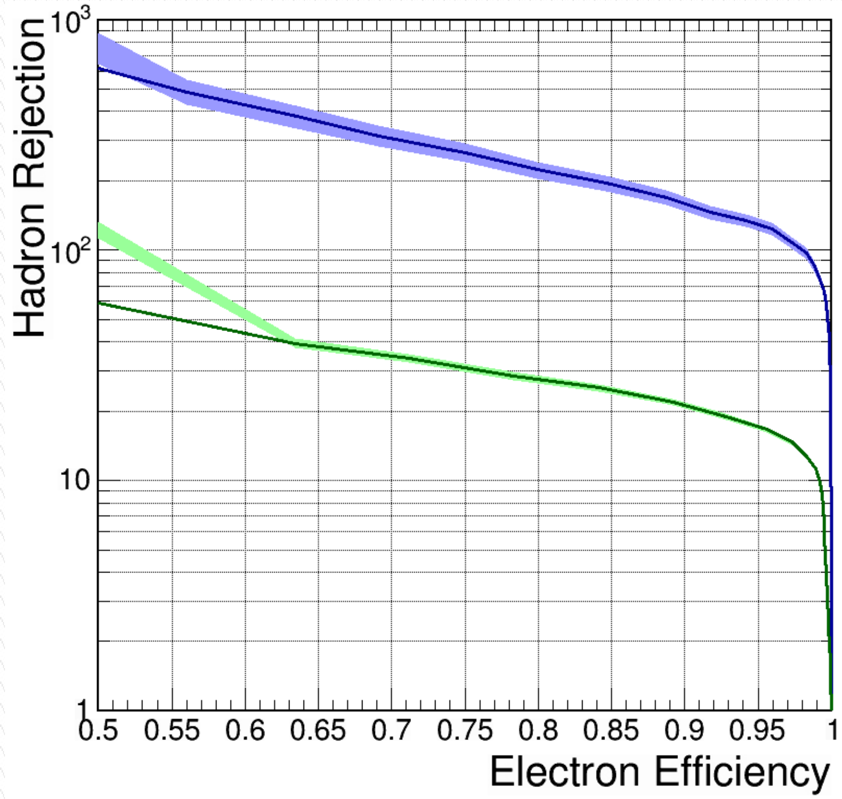
H-Cal Cut Efficiency



- Additional rejection of x2 from H-Cal
- **Total rejection ~90:1**


Pion Rejection
Electron Efficiency
Single Particle +
HIJING AuAu 0-10% Central
Geant4 eID with EMCal
$p_{e\ or\ \pi}$ = 2 GeV/c
$p_{e\ or\ \pi}$ = 4 GeV/c
$p_{e\ or\ \pi}$ = 8 GeV/c

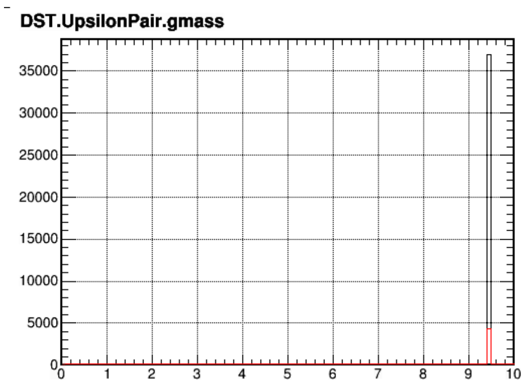

Hadron Rejection
Electron Efficiency

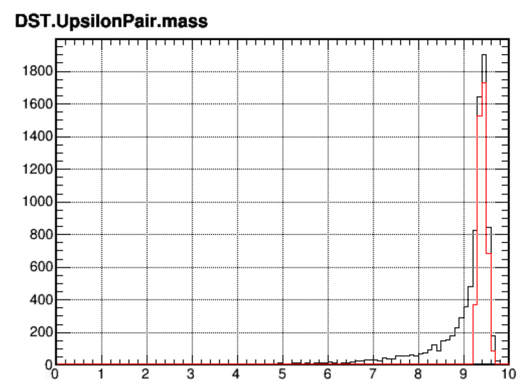


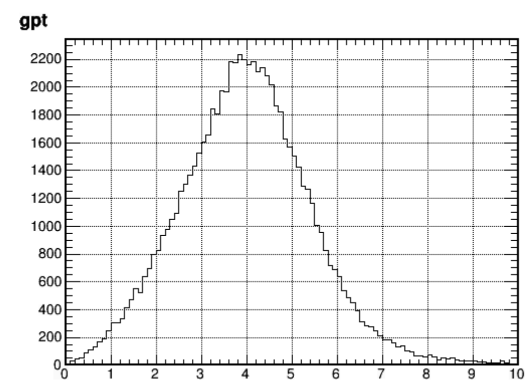
Hadron Rejection
10^3
10^2
10
1
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
Electron Efficiency

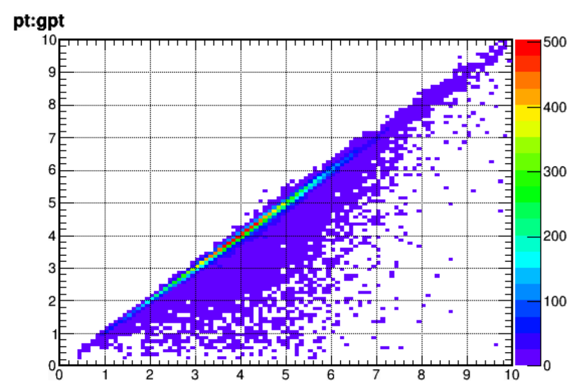
SPACAL 1D

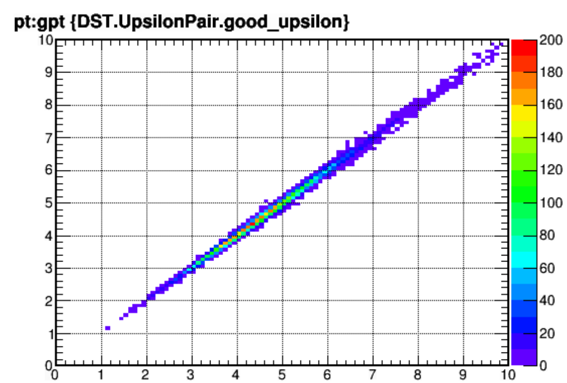
Upsilon simulation and selection



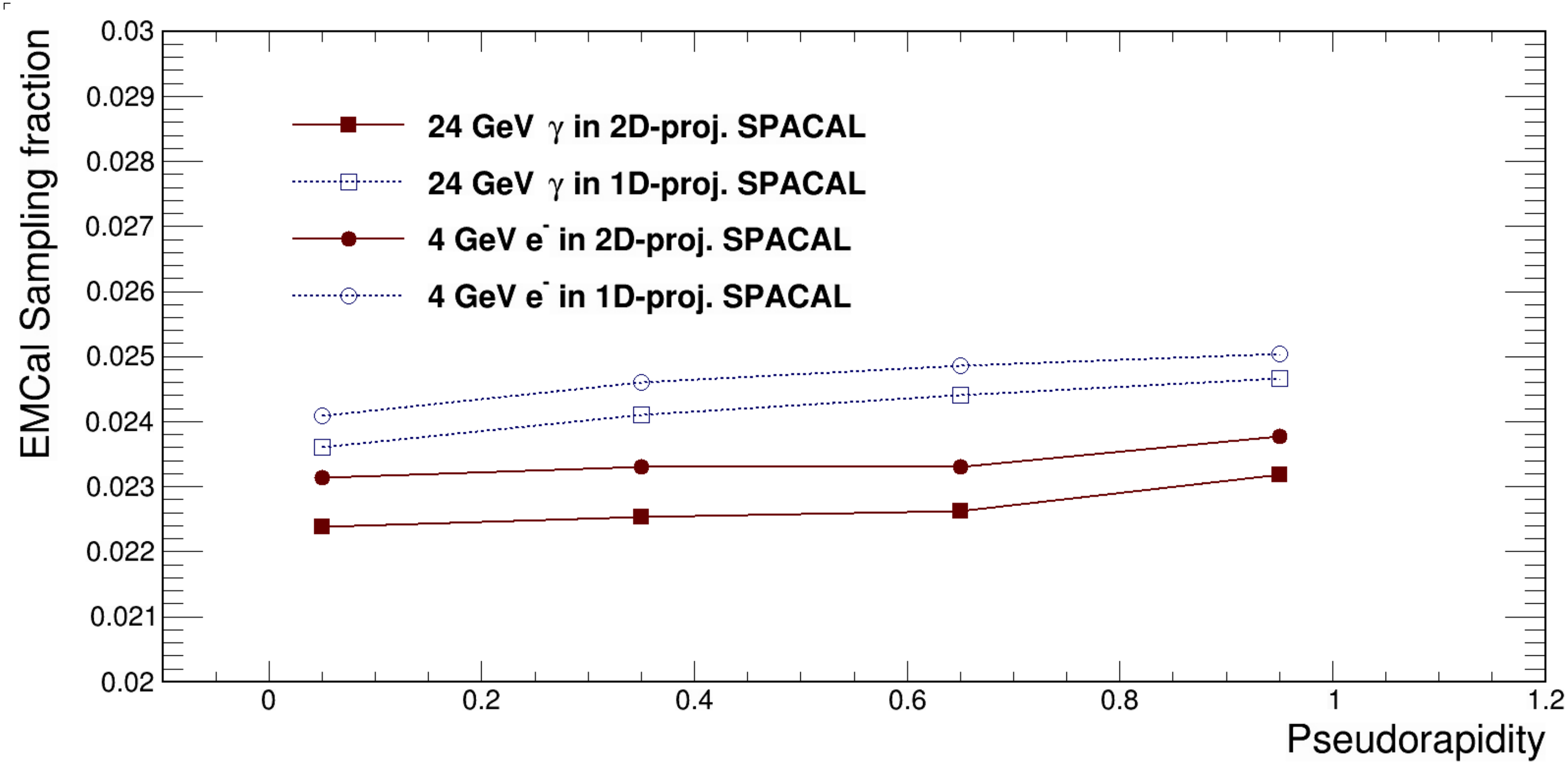






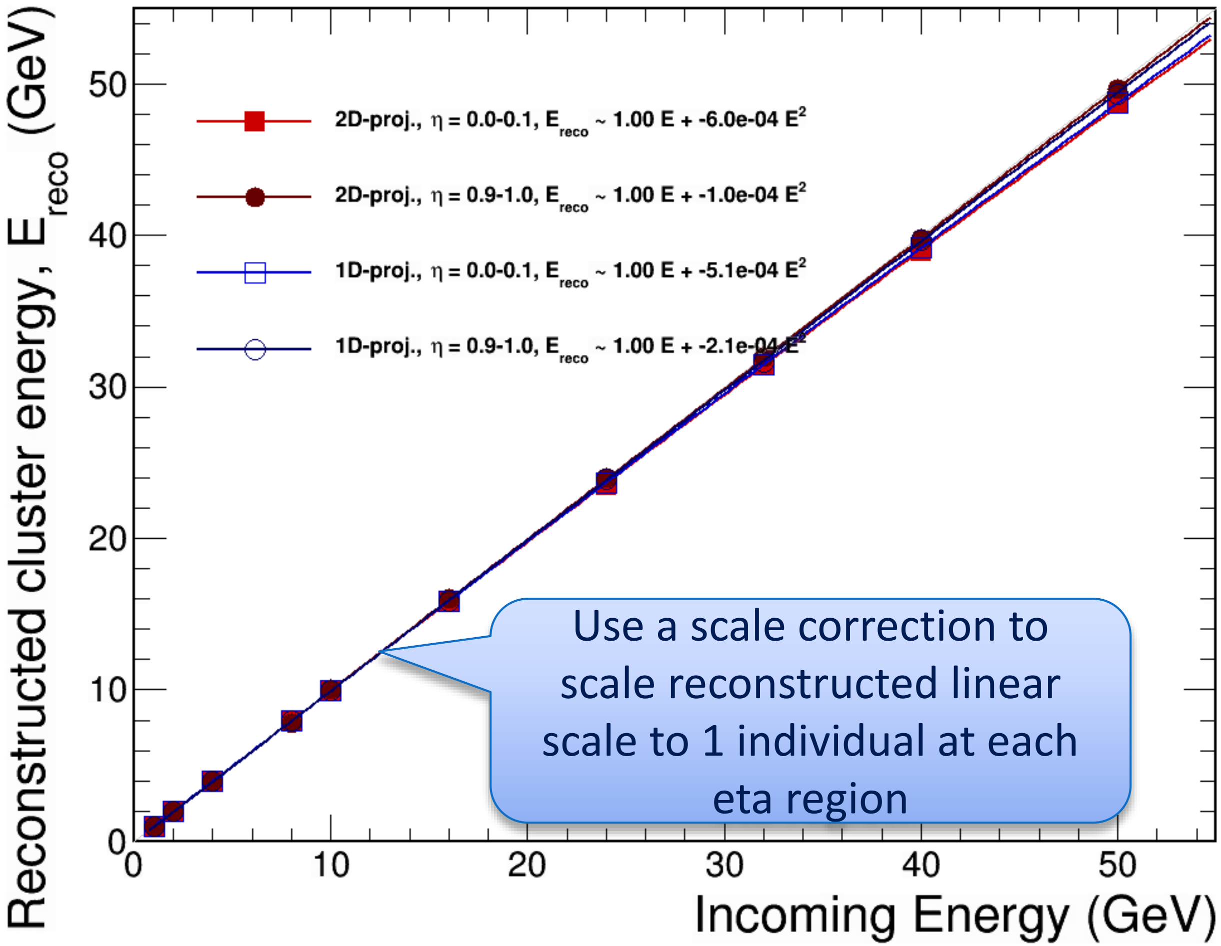


Sampling Fraction



/direct/phenix+sim02/phnxreco/ePHENIX/jinhuang/sPHENIX_work/single_particle/DrawEcal_DrawSF.pdf

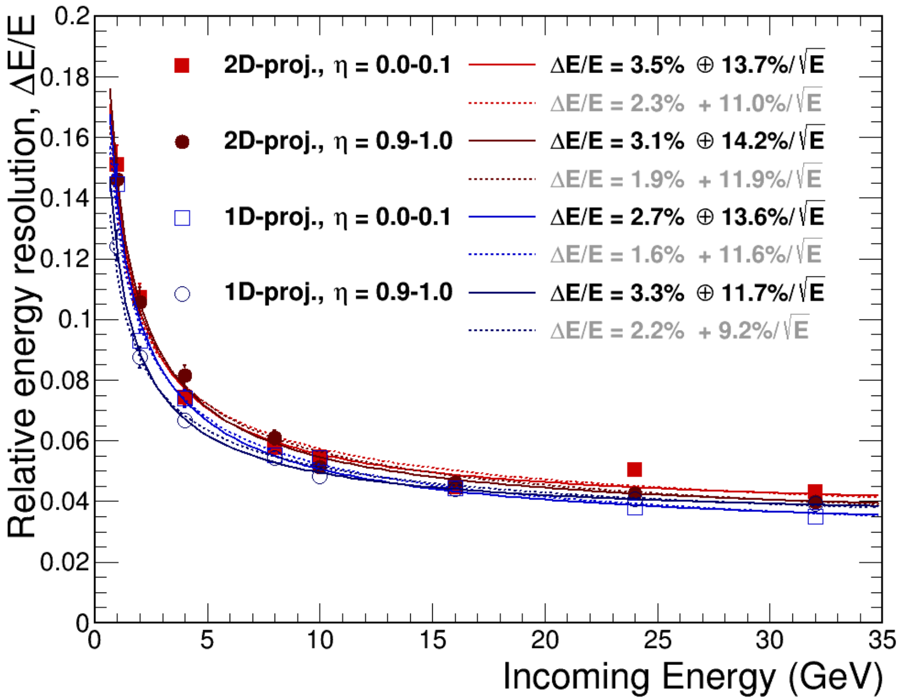
Linearality – double checking



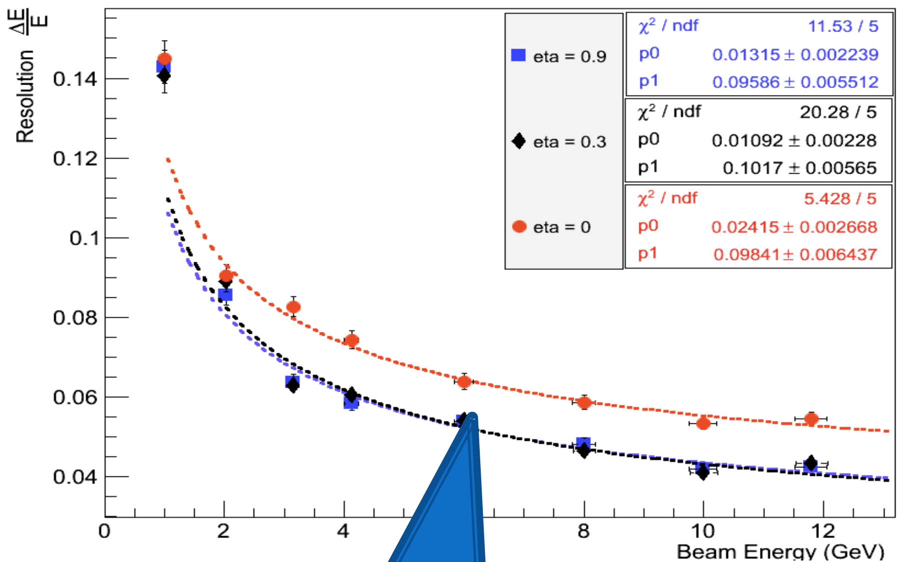
Energy resolution
Simulated with single photons

Full detector Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (8pe), photon fluctuation (500pe/GeV), Zero sup (16pe), Graph clusterizer

sPHENIX full detector single photon simulation



EIC RD1 study
FermiLab beam tests



Courtesy: A.Kiselev (BNL)
DIS2014

Used [1] + [2]/sqrt(E) in fit
instead of sqrt sum??

Photon resolution [Megan and Stefan]

- PHENIX Clusterizer from Sasha B. survived PHENIX->sPHENIX migration.
  - Promising use of the PHENIX Clusterizer in HI embedded events
- Fit with Gaus
- [0]*exp(-0.5*((x-[1])/[2])**2)

Plots from Megan Connors (GSU)